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MR. GRANT ALLEN'S NOTIONS ABOUT FORCE AND ENERGY.

Force and Energy: a Theory of Dynamics. By Grant Allen. Pp. 161. (Longmans, Green, and Co., 1888.)

THERE exists a certain class of mind, allied perhaps to the ancient Greek Sophist variety, to which ignorance of a subject offers no sufficient obstacle to the composition of a treatise upon it. It may be rash to suggest that this type of mind is well developed in philosophers of the Spencerian school, though it would be possible to adduce some evidence in support of such a suggestion.

In the volume before us Mr. Grant Allen sets to work to reconstruct the fundamental science of dynamics, an edifice which, since the time of Galileo and Newton, has been standing on what has seemed a fairly secure and substantial basis, but which he seems to think it is now time to demolish in order to make room for a newly excogitated theory. The attempt is audacious, and the result—what might have been expected. The performance lends itself indeed to the most scathing criticism; blunders and misstatements abound on nearly every page, and the whole structure is simply an emanation of mental fog.

Thus much it is necessary to say in order to give an adequate idea of the nature of the book; but, having said as much as this, it is possible to speak quite otherwise of the friendly tone and apparently candid modesty in which the preface has been written. The preface, indeed, almost disarms a critic, or at any rate it causes him to use the blunt end of his lance; and were it not necessary to call attention to the erroneousness of such of the doctrines as are new, and expose their hollowness to a number of unlearned persons who are always eager to see some flaw found in a universally accepted theory the difficulties of which they have never mastered, and which they therefore vainly hope will turn out incorrect, one would gladly accept the apology and explanation of the preface and let the work sink into oblivion unnoticed.

Its pretentious form, however, renders criticism necessary; and indeed criticism is expected by the author, though, as he naïvely confesses, it will not undermine his own opinion of the truth and value of his work.

The book is in two parts: Part I. "Abstract or Analytic"; Part II. "Concrete or Synthetic." The second part consists of more or less popular illustrations of the doctrines inculcated in the first part: it need not therefore much concern us. The first part starts with chapters on "Power," "Force," "Energy"; later on it has three chapters called respectively, "The Persistence of Force," "The Conservation of Energy," "The Indestructibility of Power." These last headings are not very promising; and the performance does not belie the promise.

Chapter II. leads off with the following definition:—

> "A Force is a Power which initiates or accelerates aggregative motion, while it resists or retards separative motion, in two or more particles of ponderable matter (and possibly also of the ethereal medium)."

In other words, the author agrees to limit the term "force" to that which is commonly known as attraction. Very good. Now take Chapter III.:—

> "An Energy is a Power which resists or retards aggregative motion, while it initiates or accelerates separative motion, in two or more particles of ponderable matter, or of the ethereal medium."

In other words, he is going to denote that which is commonly known as repulsion by the name "energy." He by no means always adheres to the limitations imposed by this definition, and frequently he means by the term energy the same as is ordinarily understood by the term, though he does so most happily in cases where the result can be looked upon as a separation of some bodies.

Thus, for instance, the upward motion of a cannon-ball he would style an energy, because it separates the ball from the earth; the strain in a bow he would call an energy, because it can separate the arrow from the bow; heat he would call energy, because it usually expands things; but the *horizontal* motion of a cannon-ball or a railway train he will have a difficulty in calling an energy, and, in fact, is unable to do so without a flagrant mistake of principle in the case of the ball, and some manifest special pleading in the case of the train. Still more unable is he properly to apply the term energy to the *downward* motion of a falling body. We shall see what he makes of this obvious difficulty shortly. Nevertheless, this is the main doctrine in the book—viz. that anything tending towards aggregation is a force, while anything tending to disgregation is an energy.

Passing, then, to the next chapter, "The Species of Force," he subdivides force into attraction between large masses, or gravitation—between molecules, or cohesion—between atoms, or chemical affinity—and, lastly, between electric charges. It may as well be said, once for all, that throughout the book there are many lame and hesitating references to electricity and ether, which are so vague as to be quite harmless, and which it will be the most charitable plan to simply ignore. We had better ignore most of the chemical and molecular statements also, for the same reason, and attend only to those which deal with ordinary lumps of matter. But even here it will not do to criticize the language too closely, or one would have enough to do. This, for instance, is one of the first sentences about gravitation: "When an aërolite comes within the circle of the earth's attraction, it is Gravitation which makes them leap towards one another." "The circle of the earth's attraction" and the sudden "leap" of the aërolite when it comes within this circle, are phrases which scarcely express quite accurately the facts of the case!

The next sentence throws a flood of light upon the state of the writer's mind when he formed his conception of the difference between force and energy, and explains also, I venture to surmise, why his doctrine found so blithe an acceptance with Mr. Edward Clodd, as Mr. Clodd's own book and the preface to this one inform us. It is the orbital energy of the moon which counteracts the aggregative power of gravity. "If the moon were to lose its orbital Energy, Gravitation would pull it to the earth."

This sentence is not indeed untrue, but it is significant as showing that it is the old puzzle of centrifugal force or of radial acceleration that is at the bottom of this whole "new theory." The puzzle was solved completely long ago, in the clearest possible manner, and the "Principia" is the witness to it; but it is still felt to be a difficulty by beginners, and I suppose there is no offence in applying this harmless epithet to both Mr. Grant Allen and Mr. Clodd, so far as the truths of dynamics and physics are concerned.

"Energy" and "Force" are always opposed to one another, and the meaning of the author is well illustrated by the following quotation:—

> "Again, when two masses are in a state of aggregation, the Force of gravitation resists any attempt to sever them. If a cannon-ball lies upon the ground, it cannot be raised without an expenditure of Energy, and the amount of the Energy required to lift it to a given height is the measure of the resistance offered by Gravitation."

That is to say, the energy required to lift a body to a given height is a measure of the force of gravitation. This reminds one of some of the sentences in Tyndall's "Heat."

The next chapter, "The Species of Energy," classifies energy as molar, molecular, atomic, and electrical, just as in the case of force. "Of Molar Energies employed in resistance to aggregation, the most familiar instance is that of orbital movement"— moon and earth, &c.

Now we come to the *crux* of how horizontal motion can be an "energy" in the sense defined by Mr. Allen.

> "On a smaller scale, the Energy of a bird in flying, or of a cannon-ball fired horizontally, is largely employed in counteracting gravitation"!!

May I inform the author of an elementary fact? A cannon-ball fired horizontally falls just as quickly, and reaches the ground (if flat) in precisely the same time, as if it were merely dropped; its energy of motion has no power of counteracting gravitation. The same is really true of the moon: it falls towards the earth just as much in each second as if it had no orbital velocity; in no case does motion influence the effect produced by a given force. But this is just the fact which, if he had been able to recognize it, would have saved him the trouble of writing this treatise.

I said I would charitably omit reference to the molecular, chemical, and electrical statements, but I cannot resist one quotation from the next page: "Large masses of water before freezing part with their Energy in the visible form of heated mist."

Chapter VII. is headed "The Kinds of Kinesis," by which is meant apparently the varieties of motion. Motion is subdivided, not into rotation and translation, but thus:—

> "Motion has three Kinds; . . . it may be separative, or it may be aggregative, or it may be continuous and neutral. Each species of Kinetic Energy has a form of each kind."

The author now finds it necessary to grapple with the difficulty which we guessed he would sooner or later feel, viz. how it is possible to bring falling motion, or motion of bodies towards one another, under his category of "Energies or separative Powers." A body thrown up, and a body thrown horizontally, he has already tackled by simply committing some convenient errors of fact. He surmises that such bodies fall less than they would if dropped, and thus that their energy of motion counteracts gravitation; but the case of a body thrown down is not to be thus managed, so he proceeds to get over the difficulty in three ways. First, by raising a cloud of words; second, by asserting that when a body strikes the earth, although its potential energy of separation has disappeared, yet the heat of its collision separates atoms just as much, and results in the same ultimate amount of separation again (a statement which in no sense can be considered true), so that the motion which intervened between the start and stop of the falling body "we are justified in regarding as essentially a transitory form of separative Power."

> "Throughout we see that aggregative Energy" (*i.e.* energy apparently aggregative) "is merely Potential Energy in course of transformation to another form. While the really aggregative Power of Force is causing these bodies to combine, the Energy of their motion represents for a while their original separateness, and is finally transformed into a similar separateness between other bodies."

So, while motion *from* the earth is true kinetic energy, motion *towards* it is a transitory form of potential energy, and represents for a while the original separateness of the bodies.

When a doctrine requires a statement like this to bolster it up, it is wise to take the need as a sure indication that we are somewhere off the track, and had better get back to the turning whence the path which has led us into such a jungle diverged. It is a pity the author did not take the hint thus clearly vouchsafed to him. His difficulties about understanding normal acceleration and the generality of Newton's second law were natural and excusable, though hardly the subject to write a book about; but after encountering and being worsted by this last thicket, it was very unwise to go on plunging madly forward, and exhibit his scratches as signs of victory.

But he has not yet made his last struggle into still more hopeless entanglement. Here is his third attempt at extrication:—

> "We see that the Energy of a falling body does not consist in its mere downward movement, but rather in that accelerating motion which is capable of being transformed into heat when the masses aggregate."

If this statement means anything, it means that the kinetic energy of a down-moving body consists, not in its velocity, as is the case with an upward-moving body, but in its acceleration, and that it is this acceleration which ultimately gets turned into heat!

> "So the Energy of Kinesis is seen to be a mere transferential mode from one kind of separation to another." "Motion is the redistribution of Separations."

One may at least acknowledge the ingenuity as well as the gallantry with which the author endeavours to get clear of his impenetrable jungle.

In passing, here is a curious definition of friction, given in an explanatory note.

> "From the point of view of the Force involved, friction means the cohesion which must be overcome; but from the point of view of the Energy employed, friction means the separative power of heat which overcomes."

Next we come to the extraordinary but fortunately short chapter entitled "The Persistence of Force," which "must be carefully distinguished from the opposite principle of the Conservation of Energy."

From the examples given it appears that the author means by "the persistence of force" the universal prevalence and unalterable character of gravitation. This, if you please, is a principle "opposite" to the "conservation of energy."

It may be asked how on earth the author manages to make out any doctrine of conservation for what he is pleased to style "Energy." It may be asked, but scarcely answered. First, there is a momentous difference of language to be attended to, a difference of which we are told the concrete and practical results are enormous. "While Forces *persist*, Energies are *conserved*." This is a most satisfactory beginning, and makes one feel quite smooth and comfortable. But unfortunately the author is not original in the rest of this chapter, and his illustrations of conservation of energy do not flow from his definition, but are quite common-place. I cannot resist one little extract from this chapter wherein the property of "inertia" has an altogether new light thrown upon it, a light even more brilliant than that just thrown upon "friction."

> "Two molecules of water vapour are prevented from aggregating under the relatively feeble attraction of cohesion at a distance, by their inertia—that is, by the relatively strong cohesion of surrounding or intervening matters (just as a mass on a table is prevented from aggregating with the earth by the cohesion of its boards). Two atoms having affinities for one another are similarly prevented from aggregating by inertia. . . . So also two electrical units are prevented from aggregating in the Leyden jar by the electrical neutrality of the glass partition."

Chapter X., "The Indestructibility of Power," asserts that

> "the total amount of Power, aggregative or separative, in the Universe is constant, and no Power can ever disappear or be destroyed. This sums up the two preceding generalizations of the Persistence of Force and the Conservation of Energy in one still wider generalization."

Chapter X. is very short.

The chapter on "Liberating Energies" is a dissertation on pulling a trigger, and quite mistakenly supposes that some expenditure of energy is essential to the performance of this act.

> "A ball suspended by a thread is released by the separative Energy of a knife or scissors."

The separative Energy of a knife is a good phrase.

> "The stronger Force necessarily outweighs the weaker, and as Forces cannot increase or decrease in intensity, the only manner, &c."

Forces cannot increase or decrease in intensity? No, certainly not; this is proved by the existence of the phrase "persistence of force." Well, this is logical at any rate, after the bookish manner of argument, and that is some comfort.

> "Electrical Liberating Energies are those which release Electrical Units from the interference of a Force antagonistic to Electrical Affinity."
>
> "They are such as close the circuit of a battery, or bring a discharging tongs to a Leyden jar."
>
> "The usual vagueness of electrical science prevents any definite treatment of these phenomena."

Are we, then, to conclude that the author, in all this treatise, has hit on no germ of truth—nothing but what was well known before, or what is erroneous? I fear that, with the possible exception of the idea of classifying energies by reference to the sizes of the bodies concerned, this must be our conclusion. He has regarded the universe from the point of view of action at a distance, and has been struck with one or two salient features: (1) the universality of gravitation at great distances, and of cohesion at small; (2) the existence of what has been styled "repulsive motion"—that is, a motion which simulates the effects of repulsion, as when two particles or two molecules, rushing together, swing each other round and separate again; or when a heated gas expands. One knows that, in old text-books, heat was often spoken of as a repulsive force. And a sufficient velocity imparted to a satellite *does* keep it clear of the earth.

Struck with these facts, he has proceeded to take gravitative separation as the typical and fundamental form of energy; motion being a form of energy only because it tends to separation (in some cases, at any rate), so that he defines motion, in the last chapter of Part I., as "the redistribution of separations," while energy he defines as "a Power which separates." On the other hand, he has taken gravitation and cohesion as his typical forms of force; and, because these tend to pull bodies together, he has defined force as "a Power which aggregates," and has proceeded to write a treatise on the subject, showing how force and energy are opposed to one another.

The thing which strikes one most forcibly about the physics of these paper philosophers is the extraordinary contempt which, if they are consistent, they must or ought to feel for men of science. If Newton, and Lagrange, and Gauss, and Thomson, to say nothing of smaller men, have muddled away their brains in concocting a scheme of dynamics wherein the very definitions are all wrong; if they have arrived at a law of conservation of energy without knowing what the word energy means, or how to define it; if they have to be set right by an amateur who has devoted a few weeks or months to the subject, and acquired a rude smattering of some of its terms,—what intolerable fools they must all be!

But this does seem the attitude of many literary men, and that must be one reason why they dislike and despise science. If such a view were just or true, dislike and contempt would be the only reasonable attitude.

A scientific man may often feel harassed by being unable to express in literary form what he has to say; but, though this is an evil, it is surely a lesser evil than to have the knack of writing and no matter to write. It is as when the Sophists proceeded to teach rhetoric, heedless of whether either their pupils or themselves possessed any real knowledge about which to be eloquent.

Mr. Grant Allen has apologized for his Mistake in the preface, and one has no quarrel with him. One might, if it were worth while, have a quarrel with a certain class of literary men for the shallow and flippant way in which they occasionally refer to Science; but it is not worth while.

The disciple is not above his master in this respect.

Here is one quotation of many which might have been chosen from Mr. Herbert Spencer:—

> "Newton described himself as unable to think that the attraction of one body for another at a distance could be exerted in the absence of an intervening medium. But now let us ask how much the forwarder we are if an intervening medium be assumed. This ether, whose undulations, according to the received hypothesis, constitute heat and light, and which is the vehicle of gravitation,—how is it constituted? We must regard it in the way that physicists do regard it, as composed of atoms which attract and repel each other—infinitesimal, it may be, in comparison with those of ordinary matter, but still atoms. And remembering that this ether is imponderable, we are obliged to conclude that the ratio between the interspaces of these atoms and the atoms themselves is incommensurably greater than the like ratio in ponderable matter; else the densities could not be incommensurable. Instead, then, of a direct action by the sun upon the earth, without anything intervening, we have to conceive the sun's action propagated through a medium whose molecules are probably as small relatively to their interspaces as are the sun and earth compared with the space between them; we have to conceive these infinitesimal molecules acting on each other through absolutely vacant spaces which are immense in comparison with their own dimensions. How is this conception easier than the other? We still have mentally to represent a body as acting where it is not, and in the absence of anything by which its action may be transferred; and what matters it whether this takes place on a large or a small scale?" (" First Principles," chap. iii. § 18).

Omitting any reference to the absurd reasoning about "incommensurable" densities in this quotation, and about the ether being "imponderable," as if Mr. Herbert Spencer or anyone else knows anything whatever on the subject, I wish to call attention to the words regarding the structure of the ether "in the way physicists do regard it"! If they do, if they are unable to see that action at a distance across a small space is just as inexplicable as action at a distance across a large one, and if the ether they imagine is not thought of as in some sense or other a *continuum* for this very reason; if, in fact, they are unable to appreciate, in all the years they have been thinking on the subject, what is obvious on the face of it to someone who steps in, so to speak, for the first time,—what singularly incompetent persons they must be!

That seems to be the real upshot and natural meaning of many of these criticisms of science from the outsider's point of view.

O. J. LODGE.

ROCKS AND SOILS.

Rocks and Soils: their Origin, Composition, and Characteristics. By Horace Edward Stockbridge, Ph.D., Professor of Chemistry and Geology in the Imperial College of Agriculture, Sapporo, Japan; Chemist to the Hokkaido Cho. (New York: John Wiley and Sons. London: Trübner. 1888.)

CHEMIST to the Hokkaido Cho! It is not the least striking feature of our time that there should be an Imperial College of Agriculture at Sapporo whose Professors publish researches in New York and London. This is not exactly a novel experience, for events crowd upon us thick and fast in these days; but those of us who can look back forty years must be struck when confronted with the Chemist of the Hokkaido Cho. Dr. Stockbridge is not, be it understood, the alchemist to an Eastern potentate, nor yet one of the astrologers, Chaldæans, or soothsayers of a modern Belshazzar, but an agricultural chemist and geologist discoursing upon rocks and soils, nitrates and microbes, and suggesting processes by which atmospheric nitrogen is fixed in the soil by the action of living organisms. The great Mikado, "virtuous man," has, we know, transplanted full-grown and fully-equipped knowledge from the West to his remote dominions; and so successfully, that it has rooted, and now is become an article for exportation—as witness the volume before us. To some of our readers it may appear unnecessary to dilate upon a fact which springs naturally out of the most recent developments of civilization. We need not now despair of openings for aspiring young chemists under the protection and pay of the King of Dahomey or of Ashantee, or of an Imperial Institute at Khartoum or some other part of the Dark Continent; and truly the missionaries of science are in a fair way to rival those of religion in their ubiquity.

The volume before us is of attractive appearance. It is, however, hard upon the reader who takes it up in order to learn something about rocks and soils to be carried through the entire history of the planet on which his lot is cast. Deeply interesting as are the cosmic questions bearing upon the original nebulous mist, "in glowing gaseous condition," they scarcely affect even scientific agriculture. Besides, it is open to doubt whether an agricultural chemist and geologist is within his province in explaining the differences between white stars, red stars, and habitable planets which have gone through phases thus indicated. Such information belongs to the domain of the astronomer and the physicist, and the agricultural study of rocks and soils should be taken up at a later date of the earth's history. It is not our object to criticize Dr. Stockbridge's book severely, but it appears to us that if he had cut out 100 pages at the beginning, and added 100 pages at the end in harmony with his concluding sections, his work would have been more useful.

The two features of this book which seem to us the most important are, first, Dr. Stockbridge's views as to the "fixation of atmospheric nitrogen independent of ammoniacal condensation and of nitrification." The compounds thus formed in the soil are, we are told, complex insoluble amides resembling those existing in living organisms, and must have resulted through the vital activity of the micro-organisms present in the soil. If soils have the power of fixing atmospheric nitrogen through the action of living organisms, they possess a means of recruiting fertility independent of plant action, and of so fundamental a nature that, supposing such action to take place, the question of the source of nitrogen and the supply of nitrogen in soils would be set at rest. Another novel view is that propounded with reference to dew-formation. Here, we have a subject which is not very clearly related to that of rocks and soils. So far as the soil is a vehicle of plant nutrition, its conditions as related to moisture are of course important, and it is in this connection that the theory of dew as propounded by Dr. Stockbridge finds a place in his work. It is not necessary here to explain Dr. Wells's explanation of the fall of dew.